CLAIMS

What is claimed is:

1. A method of communicating optical signals over a free-space link, comprising the steps of:

receiving a first optical signal having a fiber interface fundamental wavelength from a first single mode optical fiber;

converting the fiber interface fundamental wavelength of the first optical signal to a free-space fundamental wavelength with a transmit wavelength transformer;

directing the first optical signal having the free-space fundamental wavelength over the free-space link;

receiving a second optical signal having the free-space fundamental wavelength from the free-space link;

converting the free-space fundamental wavelength of the second optical signal to a fiber interface fundamental wavelength with a receive wavelength transformer; and

directing the second optical signal having the fiber interface fundamental wavelength into a second single mode optical fiber.

2. A method in accordance with claim 1, wherein the step of converting the fiber interface fundamental wavelength of the first optical signal to a free-space fundamental wavelength is performed all-optically without using electro-optical conversion.

3. A method in accordance with claim 2, wherein the step of converting the free-space fundamental wavelength of the second optical signal to a fiber interface fundamental wavelength is performed all-optically

without using electro-optical conversion.

4. A method in accordance with claim 2, wherein the step of converting the free-space fundamental wavelength of the second optical signal to a fiber interface fundamental wavelength is performed using optical-to-electrical conversion.

5. A method in accordance with claim 1, further comprising the steps of:

sampling a portion of the second optical signal having the free-space fundamental wavelength; and

using the sampled portion of the second optical signal in an offline path to determine a new value for the free-space fundamental wavelength.

6. A method in accordance with claim 5, wherein the step of using the sampled portion of the second optical signal in an offline path to determine a new value for the free-space fundamental wavelength comprises the step of:

comparing a detected offline performance with a detected online performance.

7. A method in accordance with claim 5, further comprising the step of:

reconfiguring the transmit wavelength transformer to convert the fiber interface fundamental wavelength of the first optical signal to the new value for the free-space fundamental wavelength.

8. A method in accordance with claim 1, further comprising the step of:

receiving an indication of a new value for the free-space fundamental wavelength via an out-of-band communications channel.

9. A method in accordance with claim 8, further comprising the step of:

reconfiguring the transmit wavelength transformer to convert the fiber interface fundamental wavelength of the first optical signal to the new value for the free-space fundamental wavelength.

10. A method in accordance with claim 1, further comprising the step of:

sampling a portion of the first optical signal having the free-space fundamental wavelength;

sampling a portion of the second optical signal having the free-space fundamental wavelength;

comparing a wavelength of the sampled portion of the first optical signal to a wavelength of the sampled portion of the second optical signal.

11. A method in accordance with claim 10, further comprising the step of:

reconfiguring the transmit wavelength transformer in response to a measured deviation between the wavelength of the sampled portion of the first optical signal and the wavelength of the sampled portion of the second optical signal.

12. An apparatus for communicating optical signals over a free-space link, comprising:

means for receiving a first optical signal having a fiber interface fundamental wavelength from a first single mode optical fiber;

a transmit wavelength transformer configured to convert the fiber interface fundamental wavelength of the first optical signal to a free-space fundamental wavelength;

a transmitting element configured to direct the first optical signal having the free-space fundamental wavelength over the free-space link;

a receiving element configured to receive a second optical signal having the free-space fundamental wavelength from the free-space link;

a receive wavelength transformer configured to convert the free-space fundamental wavelength of the second optical signal to a fiber interface fundamental wavelength; and

means for directing the second optical signal having the fiber interface fundamental wavelength into a second single mode optical fiber.

13. An apparatus in accordance with claim 12, wherein the transmit wavelength transformer comprises an apparatus for converting the fiber interface fundamental wavelength of the first optical signal to a free-space fundamental wavelength all-optically without using electro-optical conversion.

14. An apparatus in accordance with claim 13, wherein the receive wavelength transformer comprises an apparatus for converting the free-space fundamental wavelength of the second optical signal to the fiber interface fundamental wavelength all-optically without using electro-optical conversion.

15. An apparatus in accordance with claim 13, wherein the receive wavelength transformer comprises an apparatus for converting the free-space fundamental wavelength of the second optical signal to the fiber interface fundamental wavelength using optical-to-electrical conversion.

16. An apparatus in accordance with claim 12, further comprising:

a controller configured to compare a detected offline performance with a detected online performance to determine a new value for the free-space fundamental wavelength.

17. An apparatus in accordance with claim 16, wherein the controller is further configured to reconfigure the transmit wavelength transformer to convert the fiber interface fundamental wavelength of the first optical signal to the new value for the free-space fundamental wavelength.

18. An apparatus in accordance with claim 12, further comprising:

an out-of-band communications channel configured to receive an indication of a new value for the free-space fundamental wavelength.

19. An apparatus in accordance with claim 18, further comprising:

a controller configured to reconfigure the transmit wavelength transformer to convert the fiber interface fundamental wavelength of the first optical signal to the new value for the free-space fundamental wavelength.

20. An apparatus in accordance with claim 12, further comprising:

a controller configured to compare a wavelength of a sampled portion of the first optical signal to a wavelength of a sampled portion of the second optical signal.

21. An apparatus in accordance with claim 20, wherein the controller is further configured to reconfigure the transmit wavelength

transformer in response to a measured deviation between the wavelength of the sampled portion of the first optical signal and the wavelength of the sampled portion of the second optical signal.

22. A method of communicating optical signals over a free-space link, comprising the steps of:

receiving a first optical signal having a fiber interface fundamental wavelength from a first single mode optical fiber;

amplifying the first optical signal with a multi-wavelength optical amplifier connected in-line with the first single mode optical fiber;

attenuating the first optical signal with a variable optical attenuator that is optically coupled to the multi-wavelength optical amplifier;

converting the fiber interface fundamental wavelength of the first optical signal to a free-space fundamental wavelength with a transmit wavelength transformer; and

directing the first optical signal having the free-space fundamental wavelength over the free-space link.

23. A method in accordance with claim 22, wherein the step of converting the fiber interface fundamental wavelength of the first optical signal to a free-space fundamental wavelength is performed all-optically without using electro-optical conversion.

24. A method in accordance with claim 22, further comprising the step of:

reconfiguring the transmit wavelength transformer to convert the fiber interface fundamental wavelength of the first optical signal to a new value for the free-space fundamental wavelength.

25. A method in accordance with claim 24, further

comprising the step of:

comparing a detected offline performance with a detected online performance to determine the new value for the free-space fundamental wavelength.

26. A method in accordance with claim 24, further comprising the step of:

receiving an indication of the new value for the free-space fundamental wavelength via an out-of-band communications channel.

27. A method in accordance with claim 24, further comprising the step of:

sampling a portion of the first optical signal having the free-space fundamental wavelength;

receiving a second optical signal having the free-space fundamental wavelength from the free-space link;

sampling a portion of the second optical signal having the free-space fundamental wavelength; and

comparing a wavelength of the sampled portion of the first optical signal to a wavelength of the sampled portion of the second optical signal to determine the new value for the free-space fundamental wavelength.

28. A method in accordance with claim 22, further comprising the step of:

controlling a power gain of the multi-wavelength optical amplifier and a dynamic attenuation provided by the variable optical attenuator.

29. An apparatus for communicating optical signals over a free-space link, comprising:

means for receiving a first optical signal having a fiber interface fundamental wavelength from a first single mode optical fiber;

a multi-wavelength optical amplifier connected in-line with the first single mode optical fiber for amplifying the first optical signal;

a variable optical attenuator that is optically coupled to the multi-wavelength optical amplifier for attenuating the first optical signal;

a transmit wavelength transformer configured to convert the fiber interface fundamental wavelength of the first optical signal to a free-space fundamental wavelength; and

one or more transmitting elements configured to direct the first optical signal having the free-space fundamental wavelength over the free-space link.

30. An apparatus in accordance with claim 29, wherein the transmit wavelength transformer comprises an apparatus for converting the fiber interface fundamental wavelength of the first optical signal to a free-space fundamental wavelength all-optically without using electro-optical conversion.

31. An apparatus in accordance with claim 29, further comprising:

a controller configured to reconfigure the transmit wavelength transformer to convert the fiber interface fundamental wavelength of the first optical signal to a new value for the free-space fundamental wavelength.

32. An apparatus in accordance with claim 31, wherein the controller is further configured to compare a detected offline performance with a detected online performance to determine the new value for the free-space fundamental wavelength.

33. An apparatus in accordance with claim 31, wherein the controller is further configured to receive an indication of the new value for the free-space fundamental wavelength via an out-of-band communications channel.

34. An apparatus in accordance with claim 29, further comprising:

a controller configured to control a power gain of the multi-wavelength optical amplifier and an attenuation provided by the variable optical attenuator.

35. A method of communicating optical signals over a free-space link, comprising the steps of:

receiving a first optical signal having the free-space fundamental wavelength from the free-space link;

converting the free-space fundamental wavelength of the first optical signal to a fiber interface fundamental wavelength with a receive wavelength transformer;

amplifying the first optical signal with a multi-wavelength optical amplifier optically coupled to the receive wavelength transformer;

attenuating the first optical signal with a variable optical attenuator that is optically coupled to the multi-wavelength optical amplifier; and

directing the first optical signal having the fiber interface fundamental wavelength into a first single mode optical fiber.

36. A method in accordance with claim 35, wherein the step of converting the free-space fundamental wavelength of the first optical signal to a fiber interface fundamental wavelength is performed all-optically without using electro-optical conversion.

37. A method in accordance with claim 35, wherein the step of converting the free-space fundamental wavelength of the first optical signal to a fiber interface fundamental wavelength is performed using optical-to-electrical conversion.

38. A method in accordance with claim 35, further comprising the step of:

reconfiguring the receive wavelength transformer to convert a new value for the free-space fundamental wavelength of the first optical signal to the fiber interface fundamental wavelength.

39. A method in accordance with claim 38, further comprising the step of:

comparing a detected offline performance with a detected online performance to determine the new value for the free-space fundamental wavelength.

40. A method in accordance with claim 38, further comprising the step of:

receiving an indication of the new value for the free-space fundamental wavelength via an out-of-band communications channel.

41. A method in accordance with claim 38, further comprising the step of:

sampling a portion of the first optical signal having the free-space fundamental wavelength;

comparing a wavelength of the sampled portion of the first optical signal to a wavelength of a sampled portion of the second optical signal to determine the new value for the free-space fundamental wavelength.

42. A method in accordance with claim 35, further comprising the step of:

controlling a power gain of the multi-wavelength optical amplifier and an attenuation provided by the variable optical attenuator.

43. An apparatus for communicating optical signals over a free-space link, comprising:

a receiving element configured to receive a first optical signal having the free-space fundamental wavelength from the free-space link;

a receive wavelength transformer configured to convert the free-space fundamental wavelength of the first optical signal to a fiber interface fundamental wavelength;

a multi-wavelength optical amplifier optically coupled to the receive wavelength transformer for amplifying the first optical signal;

a variable optical attenuator that is optically coupled to the multi-wavelength optical amplifier for attenuating the first optical signal; and

means for directing the first optical signal having the fiber interface fundamental wavelength into a first single mode optical fiber.

44. An apparatus in accordance with claim 43, wherein the receive wavelength transformer comprises an apparatus for converting the free-space fundamental wavelength of the first optical signal to the fiber interface fundamental wavelength all-optically without using electro-optical conversion.

45. An apparatus in accordance with claim 43, wherein the receive wavelength transformer comprises an apparatus for converting the free-space fundamental wavelength of the first optical signal to the fiber interface fundamental wavelength using optical-to-electrical conversion.

46. An apparatus in accordance with claim 43, further comprising:

a controller configured to reconfigure the receive wavelength transformer to convert a new value for the free-space fundamental wavelength of the first optical signal to the fiber interface fundamental wavelength.

47. An apparatus in accordance with claim 46, wherein the controller is further configured to compare a detected offline performance with a detected online performance to determine the new value for the free-space fundamental wavelength.

48. An apparatus in accordance with claim 46, wherein the controller is further configured to receive an indication of the new value for the free-space fundamental wavelength via an out-of-band communications channel.

49. An apparatus in accordance with claim 46, wherein the controller is further configured to compare a wavelength of a sampled portion of the first optical signal to a wavelength of a sampled portion of a second optical signal to determine the new value for the free-space fundamental wavelength.

50. An apparatus in accordance with claim 43, further comprising:

a controller configured to control a power gain of the multi-wavelength optical amplifier and an attenuation provided by the variable optical attenuator.